

## FISHERIES RESOURCES OF VICTORIA'S COASTAL AND OFFSHORE WATERS

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**ABSTRACT:** Information available from fisheries surveys and from records of commercial catches are used to describe, as far as possible, the distributions, movement patterns and abundances of species forming the demersal and pelagic fisheries resources of Victoria's coastal and offshore waters. A quantitative assessment of the total resource is precluded because most of the surveys have been unrelated and because many of the commercial fisheries are localised. Species which are only caught incidentally or are unexploited but have the potential of supporting a commercial fishery are also discussed.

Some of the region's physical characteristics, including the topography of the continental shelf and upper continental slope and the daily and seasonal water movement patterns which influence the fisheries resources, are briefly described.

### INTRODUCTION

During recent years reviews of the Victorian fishing industry (Burdon 1973), surveys of major fisheries in southeastern Australian waters (Anon. 1976a) and descriptions of the fish species present in Victorian waters (Anon. 1967) have been published, but in no publication has there been an attempt to collate the available information required to describe Victoria's ocean fisheries resources. After a century of commercial fisheries development, until recently unaided by research and sophisticated management, a review of such information is timely because the fishing industry, the community and the government are concerned about development prospects and management issues attendant on the proclamation of the 200-mile Australian Fishing Zone.

State and Commonwealth authorities have recently been re-examining data previously collected to serve local fisheries management and development purposes. The authorities' aims were to estimate the sustainable catch which each species could support, to determine the local fleet's catching capability and to decide how foreign interests might participate in exploiting these resources.

Strictly speaking, Victorian waters east of longitude 143° 40'E extend into Bass Strait only as far south as latitude 39° 12'S, that is 4 n mile south of Wilsons Promontory; the southern boundary

west of that longitude in 40°S. Fisheries resources which Victorian-based fishermen exploit north and south of the boundary are considered together below.

### TOPOGRAPHY OF THE SEABED OFF VICTORIA

#### BASS STRAIT

In Bass Strait oceanic swells, daily tidal currents and seasonal oceanic currents from the Great Australian Bight, Tasman Sea and sub-Antarctic waters have produced complex topographic and oceanographic conditions.

Bass Strait has a central basin 65-90 m deep with irregular bottom formations (undulations, scoured rocky areas and coarse sediment deposits) where currents are strongest, at its eastern and western entrances. Fine sand and mud also occur in the central basin.

Banks of fine sediment occur off the eastern Otway coast and from south of Phillip Island towards Wilsons Promontory. A sedimentary seafloor in shallow water occurs east and north-east of King Island.

In western Bass Strait, a depression caused by subsidence between fault lines (Keble 1946) and by fluvial erosion in the former Tamar Major river system (Dannevig 1915) extends from between King Island and Cape Otway in a north-easterly

direction towards Point Nepean, decreasing in depth from 100 m to 86 m, then along the Victorian coast to Phillip Island and south into the central basin. Numerous islands including the Curtis, Hogan and Kent Groups are situated between Wilsons Promontory and Flinders Island where current activity has produced a variety of bottom types including: rocky, bryozoan and sponge covered, gravel, shell and coarse sand. Areas of bryozoans and sponges, shells and coarse sands also occur east of the passage to the edge of the continental shelf.

#### CONTINENTAL SHELF OFF EASTERN VICTORIA

The continental shelf narrows from 100 n miles wide east of Wilsons Promontory to 10 n miles east of Cape Howe. In the oil and gas fields south-east of Lakes Entrance, there are restrictions placed on commercial fishing near drilling platforms, pipelines and wellheads.

Off far eastern Victoria, the deeper bottom (90-550 m) is covered with fine sediments and is even except for deep indentations or submarine canyons south of Marlo, Rame Head and Little Rame Head. The shallower bottom is predominantly coarse sand with areas of rocky outcrop.

#### CONTINENTAL SHELF OFF WESTERN VICTORIA

A prominent feature of the continental shelf off western Victoria is a rocky slope which starts in the west off Cape Duquesne, in water 60-90 m deep and becomes steeper and deeper to the south-east, converging towards the edge of the shelf south of Warrnambool. North of this slope, the bottom is largely rock or coarse sediment with extensive areas covered by bryozoans, shells and sponges. Sandy bottoms and seagrass beds occur in Portland Bay and Bridgewater Bay.

South of the rocky slope, the continental shelf is covered with fine sediments and narrows from 15 n miles south of Cape Nelson to 5 n miles south of Warrnambool. Much of the upper continental slope (220-770 m deep) from west of Robe to south of Warrnambool is covered with fine sand or mud and is trawlable. The continental slope is cut by steep canyons in a group south-west and south of Cape Bridgewater and irregularly between there and the Warrnambool area.

Upwellings off eastern and western Victoria (Rochford 1977a, 1977b) and the variable seasonal intrusions of three primary water masses (Newell 1961) must also influence the distribution, abundance and behaviour of fisheries resources off Vic-

toria but these influences are at best poorly understood.

#### SURVEYS OF FISH RESOURCES

The first important exploratory fishing program designed to assess the demersal fish and invertebrate resources of eastern Victoria and Bass Strait was conducted by the F.I.S. *Endeavour* between 1909 and 1914. The Commonwealth Government's commitment to the program is evident from the quality of the ship, of her company and of the scientists who subsequently described the biological material collected. A study of the distribution and abundance of marketable fishes and their ecological associations was in progress when the *Endeavour* was lost at sea in 1914. Since then no comparable program has been conducted in the region.

The results of the *Endeavour's* cruises still provide the most comprehensive descriptions of demersal and some pelagic species off Victoria. The outer part of the continental shelf and the upper continental slope between Gabo Island and Flinders Island were declared suitable for demersal trawling and the fish stocks were identified.

Subsequent trawling surveys in this area (Amos 1976a, Anon. 1977, 1979) and commercial trawling activity have qualified these earlier conclusions by identifying submarine canyons and foul ground, but proving conclusively the suitability of much of the bottom for demersal trawling.

Recent surveys (Anon. 1977, 1979, Gresik 1977) and resultant commercial trawling have also identified the extent of clear trawl ground and the demersal fish resources on the upper continental slope off western Victoria.

Early attempts to utilise pelagic species commercially provided some insight into their extent but most of the information on these resources results from detailed investigations of fish populations. An exception is Gould's squid *Nototodarus sloani gouldi* (McCoy); in this instance the first evidence that the species could support a substantial fishery off Victoria was the result of a feasibility study (Millington 1979).

#### COMMERCIAL FISHERIES DATA

Between 1914 and 1963, summaries of the monthly catch of each species landed at each port were the only records of the Victorian commercial catch. These summaries were used mainly to monitor the progress of the fisheries. During the 1950s, an estimate of fishing effort was used to provide more detailed information on changes in

the fisheries and in the abundance of the exploited segment of the resources.

Since July 1963, more details of catch and fishing effort have been collected from fishermen and have been used to monitor and manage the fisheries. During this period, a program of measuring samples of commercial catches of selected species has enabled the size and the sex composition of the total catches of these species to be estimated and monitored.

Thus a series of data which has become progressively more detailed has been collected and used to varying degrees by research and management workers. As a result, some characteristics of the exploited segment of several resources can be defined. The extent to which these fisheries data can be used to define the abundance of an exploited species throughout its range is limited by the distribution of the fishery in relation to that range, and by the uncertain relationships between catch rate and abundance for most species. An example is snoek *Leionura atun* (Euphrasen), a species which migrates long distances. Part of the snoek population in Bass Strait occurs seasonally in surface waters at varying distances off the central and western Victorian ports from which fishing is conducted by small, short-ranged boats. Because the main fishing method, trolling, depends on the response of the fish to the jig, fishing success varies with the distribution and abundance of food as well as that of the snoek itself. Consequently few inferences about the snoek population can be drawn from available data.

For species which are exploited through their entire range the fishery data can be extrapolated to allow an assessment of the total population. Although assessments of this kind are in progress, no quantitative estimate of a fishery resource in Victorian or nearby waters has been published.

Furthermore data for most species have not been summarised since 1974 so it is not possible to produce a chart showing distribution of recent commercial catches by statistical block or region.

Biological and population studies of fish exploited off Victoria have usually been localised relative to the overall distribution of the species. Such studies have been concerned mainly with those aspects which have a direct bearing on fisheries management of a species, for instance growth, movements, maturity and fecundity.

The assumptions and estimating procedures used for assessments, together with the types of fisheries data and population information available, have served the immediate management

purposes without a need for comprehensive ecological information. So, when a shark fisherman, a snapper angler or a penguin lover speculates on the ecological consequences of large-scale squid fishing, there may be sufficient facts known and safeguards taken to satisfy management authorities but these may not be tangible enough to dispel the fears of the questioner.

In the following sections, the results of biological and population studies and inferences from commercial fisheries statistics are used to describe the distributions, abundances, seasonal movements and some ecological determinants of exploited or potentially exploitable species off Victoria.

No attempt is made to describe the fisheries, the biology of the species or to quantify the fish resources from unpublished data. Also, because knowledge of the distributions of most species is so vague or fragmentary, no attempt has been made to map their distributions.

Many species which are commercially exploited by small inshore fisheries or are taken incidentally in larger inshore or offshore fisheries are not discussed in this paper because their numbers appear to be small or their development potential poor.

#### ABALONE

The species of abalone forming most of the Victorian catch is the blacklip abalone *Haliotis ruber* Leach which inhabits coastal reefs from the shore to depths of 30 m. These reefs are discontinuous from Discovery Bay to Warrnambool, Torquay to Wilson's Promontory (including Port Phillip) and Marlo to Cape Howe, but virtually continuous between Warrnambool and Torquay. Adult blacklip abalone occupy caves, crevices and steep rock faces exposed to water movements (Shepherd 1973). Juveniles occupy narrow crevices and the undersides of rocks and boulders.

This species is exploited over most of its range off Victoria; the total area of reef on which blacklip abalone are caught has been estimated as 6 000 ha (Anon. 1976a). Fishing intensity varies with degree of exposure of the reefs and with the distance of the reefs from fishing ports. Since the fishery was started almost two decades ago, fishing effort has fluctuated, but the species seems capable of supporting an annual catch of about 1 400 tonnes.

The other species exploited commercially is the greenlip abalone *Haliotis laevigata* Donovan which also occurs on rocky bottoms from the shore to depths of 30 m, usually in areas of

moderate water movement (Shepherd 1973) along rocky channels or gutters and close to the interface between rock and sand or seagrass beds. In Victorian waters the species is relatively uncommon and is confined to coastal reefs west of Wilsons Promontory.

#### SCALLOPS

In 1966 exploratory dredging for coastal beds of commercial scallops *Pecten alba* Tate off Victoria revealed low concentrations of the old shells of dead scallops off Cape Otway, Port Phillip Heads, Cape Schanck and Waratah Bay (Sanders 1966). Small hauls of live scallops and large hauls of dead shells were dredged east of Wilsons Promontory and off Lakes Entrance.

Since 1970, surveys and commercial dredging have shown that concentrated beds of scallops occur on fine to coarse sandy substrates within 20 n miles of Lakes Entrance. The location of the beds change, and the overall abundance of scallops varies, but collectively these beds are the main source of the 1 500-4 400 tonnes landed annually at Lakes Entrance. Scallops on the more remote beds as far east as Point Hicks, off the Kingfish oil field (south-south-east of Lakes Entrance) and towards Wilsons Promontory, show greater fluctuations in abundance and are fished intermittently.

The transient nature of individual beds may be ascribed to the ocean currents which transport pelagic larvae. Occasionally, live scallops are taken in demersal trawls, on shark-fishing gear or are washed ashore in Discovery Bay, off the east coast of the Otway Peninsula, in Waratah and Venus Bays, off the east coast of Wilsons Promontory, or off Mallacoota.

Large concentrations of commercial scallops are also fished in Port Phillip.

#### CEPHALOPODS

Gould's squid is abundant in Victorian coastal and offshore waters although only since 1979, when feasibility fishing by Japanese boats started, have fisheries agencies obtained an estimate of the resource size. During autumn 1979, 10 boats took 1 641 tonnes of squid at rates of up to 12 tonnes per boat per night. Fishing operations were conducted from south-eastern South Australian waters to Wilsons Promontory, and catch rates were highest off central Victoria in waters 60-90 m deep.

Sightings and catches indicate that squid occur off Victoria throughout the year but are least abundant in coastal waters during winter (Winstanley 1979a). Several broods of squid probably occur at different times of the year in different localities; at least 5 broods of the sub-species *N. sloani sloani* Pfeffer occur off New Zealand (Kawakami 1976) and at least 3 broods of *N. sloani gouldi* are believed to occur in Tasmanian waters (Harrison 1979).

The southern calamary *Sepioteuthis australis* Quoy & Gaimard is a pelagic cephalopod of the bays, inlets and inshore coastal waters. Although the species is actively sought by fishermen in Victoria's bays, its occurrence in coastal waters is poorly recorded through incidental catches by trawlers.

One species of octopus (of uncertain identity) is caught incidentally in rock lobster pots and is known to occur on rock bottom in coastal waters. Other species of octopus and the cuttlefishes *Architeuthis braggi* (Verco) and *Amplisepia apama* (Gray) are caught in demersal trawl and Danish seine nets on sand, gravel and stony substrates off eastern and central Victoria mainly during autumn and spring.

#### PRAWNS

Two penaeid species are exploited in eastern Victorian inlets and estuarine lakes; the eastern king prawn *Penaeus plebejus* Hess and the school prawn *Metapenaeus macleayi* (Haswell). Both species are also taken by small trawlers in coastal waters 2 to 40 m deep adjacent to Lakes Entrance. The numbers in which these species move out of the Gippsland Lakes as advanced juveniles and adults vary from year to year, for instance the commercial trawl catch was 14 tonnes in 1977 but less than one tonne in 1978. This movement into coastal waters usually occurs during January to May.

Eastern king prawns occur regularly in Corner Inlet and adjacent coastal waters, small numbers are trawled seasonally off San Remo, and some have been obtained from Western Port and Port Phillip but there is no evidence that large numbers occur regularly west of Wilsons Promontory.

Specimens of the royal red prawn *Hymenopenaeus sibogae* (de Man) have been trawled and identified in the stomach contents of fishes from the continental slope off eastern (Anon. 1977 a, Gorman & Graham 1978) and western Victoria. If they are as abundant there as they are off New South Wales they could form the basis of a future fishery.

## ROCK LOBSTER

The southern rock lobster *Jasus novaehollandiae* (Holthius) inhabits rocky ground on the continental shelf off Victoria. The reefs in these waters vary from granite off Wilsons Promontory, to aeolianite and basalt in Portland Bay and bryozoa and sponge-covered limestone in deeper waters off eastern and western Victoria.

The abundance of rock lobsters and the area of rocky ground decrease from west to east along Victoria's coast. Off western Victoria, the bottom of the offshore incline, described previously, is the seaward boundary of the commercial fishing grounds (Winstanley 1980). Small numbers of rock lobsters occur on low limestone outcrops beyond this incline at depths of 146 to 165 m. South-west of Cape Otway, several reefs rise from 60 to 80 m to 25 to 35 m. Between Cape Otway and Wilsons Promontory and around the Bass Strait islands, the rock lobsters are largely confined to coastal reefs. Off eastern Victoria, reefs suitable for rock lobsters are sparse; patches of reefs occur 3 to 5 n miles offshore from the Ninety Mile Beach to Marlo, along the coast from Marlo to Cape Howe and offshore to depths of 110 m, east of Lakes Entrance.

After more than a century of commercial fishing which has become intensive since 1960 throughout most of its range, the rock lobsters off Victoria appear capable of supporting an annual catch of about 600 tonnes including 400 tonnes from west of Cape Otway.

Recent tagging studies have not shown systematic movement patterns off western Victoria but there is evidence of south-westerly movement along the eastern Otway coast towards and beyond Cape Otway.

## SOUTHERN BAY LOBSTER

Scyllarid species occur throughout the full range of depths fished by Victorian fishermen (0 to 650 m) but only one, the southern bay lobster or Balmain bug *Ibacus incisus* (Peron), is exploited commercially.

Catches from experimental beam trawling east of Wilsons Promontory and off central Victoria (Winstanley 1977) indicated that southern bay lobsters are most abundant in water of 30 to 80 m deep; more intensive otter trawling east of Cape Woolamai (Winstanley 1979a) showed that they are most abundant on clean sandy substrates in 30 to 50 m. Commercial trawling for southern bay lobsters is most intensive in the coastal waters be-

tween Lakes Entrance and Marlo on sand and gravel substrates at depths of 2 to 40 m.

## CRABS

One species of crab, the giant crab *Pseudocarcinus gigas* (Lamarck), occurs on the continental shelf and upper continental slope off western and eastern Victoria at depths of 18-420 m. Commercial fishermen catch giant crabs in rock lobster pots set mainly at the fringes of rocky bottom and on low profile reefs at depths of 54 to 126 m off western Victoria (Winstanley 1979b).

Giant crabs are more abundant and tend to be larger (up to 10 kg) at the edge of rocky bottom; smaller giant crabs of 4 to 6 kg are more sparsely distributed on low profile reefs and on sponge and bryozoan-covered bottoms (Winstanley 1979d).

The other main commercially exploited species is the swimming crab *Ovalipes bipustulatus* (Milne-Edwards). Although swimming crabs are widely distributed on shallow sandy bottoms they are caught regularly only by small trawlers which operate in the coastal waters between Lakes Entrance and Marlo.

Another species, the great spider crab *Leptomithrax australiensis* (Miers), is frequently caught in trawls and dredges and entangled in shark gillnets. This species occurs from the shore to depths of at least 814 m off South Australia (Hale 1927) and is widely distributed and at times locally abundant on the continental shelf off Victoria. During autumn to spring divers have seen thousands of these crabs congregating at depths of 2-25 m in bay and coastal waters. Great spider crabs may be regarded as a resource with the potential for development as a commercial fishery.

## EDIBLE SHARKS

Gummy sharks *Mustelus antarcticus* Gunther and school sharks *Galeorhinus australis* (Macleay) occur on the continental shelf and upper continental slope. The former species is most abundant in coastal waters, particularly in eastern Bass Strait, where it feeds largely on benthic invertebrates, and is caught on low profile reefs, and sponge and bryozoan-covered substrates.

School sharks inhabit a similar depth range but are more abundant than gummy sharks in offshore waters. During winter, adult school sharks migrate to deeper waters off Victoria and Tasmania and into South Australian and New South Wales waters. During spring, they move back onto the continental shelf off Victoria and Tasmania. Pregnant females move into the bays

and estuaries to release their young which spend about 3 years in these sheltered waters (Anon. 1976a).

Both gummy and school sharks are effectively exploited over most of their range and Victorian annual landings average about 1 500 tonnes.

Southern saw shark *Pristiophorus nudipinnus* (Gunther), angel sharks (Squatinae) and elephant shark *Callorhynchus milii* Bory de St Vincent are an incidental but important part of the marketed catch of the shark gillnet and the trawl fisheries on the continental shelf. The common saw shark *P. cirratus* (Latham) is caught and marketed by trawlers working on the continental slope at depths down to 440 m mainly during winter; various dogfishes (Squalidae) also form part of the catch on the slope.

#### PILCHARDS, ANCHOVIES AND SPRATS

Pilchards *Sardinops neopilchardus* (Steindachner) and anchovies *Engraulis australis antipodum* Gunther are the most exploited of the clupeiform fishes in Victorian waters. Sandy sprats *Hyperlophus vittatus* (Castelnau) and blue sprats *Spratelloides robustus* Ogilby are caught with pilchards and anchovies in Victorian bays, estuaries and coastal waters. The occurrence of four species is known mainly from commercial fishing in Port Phillip and off Lakes Entrance.

Off western and central Victoria, adult pilchards occur in coastal waters during autumn and winter; off eastern Victoria they occur in coastal waters throughout the year.

Adult anchovies three years of age and older leave the bays, inlets and estuaries (except Port Phillip) and are most abundant in inshore waters between April and October each year (Blackburn & Tubb 1950). In summer they return to the protected waters to spawn. From May to October in some years, large schools of anchovies have been seen in western Victorian coastal waters.

During autumn and winter, large schools of anchovies and pilchards occur in the surface waters close to shore off eastern Victoria where they are taken in purse seines in calm seas.

#### LANTERN FISH AND LIGHTFISH

Exploratory midwater trawling has shown that lantern fish and lightfish, notably *Lampanyctodes hectoris* (Gunther) and *Maurollicus muelleri* (Gmelin), form an abundant unexploited pelagic resource at the edge of the continental shelf and the continental slope. *Lampanyctodes hectoris* has been trawled in eastern Bass Strait in May, June,

July, November and December (Anon. 1976b, 1976c, 1977c) and at the edge of the continental shelf south and east of Portland during winter (Anon. 1976c). Specimens have been identified in the stomach contents of fish caught on the continental slope south of Port Fairy in November (Winstanley 1978). *Maurollicus muelleri* has been trawled in offshore eastern Bass Strait waters in March, November and December (Anon. 1977b, 1977c).

#### COD

Southern rock cod *Pseudophycis barbatus* (Gunther) occurs on rocky bottoms, on low profile reefs and on sandy bottoms among sponges and bryozoans from the shore to depths of at least 128 m. Commercial fishing for this species has been most productive in coastal waters from Lakes Entrance to Portland between late autumn and early spring, but the species now appears to be less abundant and is taken mainly as an incidental part of the trawl and Danish seine catch. Red cod *P. bachus* (Bloch & Schneider) also occurs in commercial catches but is not distinguished from southern rock cod in the catch figures.

Ribaldo or deepsea cod *Mora dannevigii* Whitley occurs on the continental slope off eastern and western Victoria at depths of 180 to 1 100 m (Winstanley 1979c) and is caught incidentally in demersal line and trawl fisheries. The frequent occurrence of dark parasitic infestations in the flesh impairs the market value of this fish.

#### LING

At least two species of ling are exploited commercially in Victorian ocean waters: rockling *Genypterus blacodes* (Bloch & Schneider) and banded ling *G. microstomus* Regan.

Rockling inhabit reefs from the shore to depths of at least 130 m and is probably the species caught on lines and in trawls at depths of 280 to 650 m on the continental slope off eastern and western Victoria.

Banded ling occur on sand, sponge and bryozoan-covered substrates in coastal waters where they are taken in trawls.

Australian tusk *Dannevigia tusca* Whitley is trawled on the continental slope off western Victoria but unlike the previous two species, tusks are not highly regarded by consumers.

#### BLUE GRENADIER

Blue grenadier or New Zealand whiptail, *Macruronus novaezelandiae* (Hector), occurs on

the continental shelf and slope to depths of at least 730 m. Recently large catches have been taken off eastern Victoria by trawlers operating from New South Wales and catches from adjacent waters off Tasmania, South Australia and New South Wales indicate that blue grenadier are particularly abundant at depths of 366 to 800 m.

Off western Victoria, exploratory trawling (Anon. 1979, Gresik 1977) showed that blue grenadier occur mainly at depths of 290 to 550 m during autumn and winter. Recently, commercial catches have been highest at depths of 550 to 586 m from late summer to winter. Small individual fish have been caught at depths of about 10 m in Portland Bay during summer. Off eastern Victoria exploratory trawling (Anon. 1977, 1979) showed that blue grenadier occur at depths of 117 to 550 m and are most abundant at depths of 360 to 550 m during summer and autumn.

#### NANNYGAI

Nannygai or redfish *Centroberyx affinis* (Gunther) occur mainly on the continental shelf off Victoria. Nannygai are an incidental part of the demersal trawl catch at depths of 110 to 220 m off eastern Victoria and 27 to 82 m off central Victoria (mainly in autumn).

#### DORIES

Three species of dories are abundant and exploited by demersal trawling in deeper waters of the continental shelf and continental slope off eastern and western Victoria: the silver dory *Cyttus australis* (Richardson), the mirror dory *Zenopsis nebulosis* (Temminck & Schlegel) and the king dory *Cyttus traversi* Hutton. Silver dories occur in coastal water and are incidental in demersal catches but they are prominent at depths of 110 to 220 m off eastern Victoria in spring and summer and at 512 to 586 m off western Victoria for many months of the year.

During summer and autumn, mirror dories are most abundant and are trawled at depths of 110 to 512 m off eastern Victoria and 200 to 428 m off western Victoria.

The king dory is most abundant and is trawled during summer and autumn at depths of 120 to 265 m (they occur as deep as 550 m) off eastern Victoria and at depths of 220 to 586 m off western Victoria.

The John dory *Zeus faber* Linnaeus occurs from the coast to depths of at least 137 m and is largely incidental in demersal catches off eastern and central Victoria.

#### GURNARD PERCHES

One species, the ocean perch *Helicolenus papillosus* (Bloch & Schneider), is widely distributed, abundant and commercially exploited mainly by demersal trawlers.

This species, also known as coral perch, big-eye gurnard or red gurnard perch, occurs from the shore to depths of 640 m and is caught, at least in small numbers, wherever and whenever trawlers operate off Victoria.

Off eastern Victoria, ocean perch are most abundant at depths of 348 to 480 m during autumn. Off central Victoria, they are trawled in coastal waters at depths of 30 to 82 m in all months. Off western Victoria, they are regularly trawled at depths of 165 to 586 m and are particularly abundant at depths of 293 to 311 m in winter. Other gurnard perches, such as the thetis fish *Neosebastes thetidis* (Waite), are caught incidentally off Victoria but they are not identified in catch records.

#### GURNARDS

Two species of gurnard are exploited on the continental shelf; red gurnard *Chelidonichthys kumu* (Lesson & Garnot) and latchet or sharp-beaked gurnard *Pterygotrigla polyommata* (Richardson). Both are demersal, widely distributed and caught throughout the year, but large catches are seasonal.

Red gurnard occur from the shore to depths of at least 220 m and are most abundant in spring at depths of 110 to 220 m off eastern Victoria and at 20 to 90 m off central Victoria.

Latchet occur from the shore to depths of at least 550 m and are abundant at depths of 140 to 165 m in autumn off eastern Victoria, 54 to 82 m in autumn and spring off central Victoria and 124 to 132 m in autumn and winter off western Victoria.

The spiny or cocky gurnard *Paratrigla papilio* (Cuvier & Valenciennes) is abundant in coastal waters 36 to 82 m deep off central Victoria but is not commercially exploited because of its small size. Another unexploited species, the painted or spotted gurnard *Pterygotrigla picta* Gunther, is common at depths of 152 to 403 m off eastern Victoria.

#### FLATHEADS

The most commercially important species of flathead in Victorian waters, the tiger flathead, *Neoplatycephalus richardsoni* (Castelnau), predominates in the flathead caught by trawl and

Danish seine boats based at Lakes Entrance. Tiger flathead occur on sandy bottoms from the shore to depths of at least 300 m and are caught throughout the year. During summer, large schools form in water 55 to 128 m deep and during winter and spring these flathead are more widely dispersed and are most abundant in water 110 to 220 m deep.

West of Lakes Entrance, tiger flathead are less abundant and the very similar species, the toothy flathead *N. speculator* Klunzinger, is more numerous. Toothy flathead predominate in commercial catches of flatheads from continental shelf and upper continental slope (to depths of 270 m) west of Wilsons Promontory. Off central Victoria toothy flathead are most abundant during summer and autumn and are trawled at depths of 30 to 70 m.

The deepwater flathead *N. conatus* Waite & McCulloch is a small component of the demersal trawl catch taken on the continental slope off western Victoria, where it is caught in waters 250 to 310 m deep.

Sand flathead *Platycephalus bassensis* Cuvier & Valenciennes is common on shallow sandy bottoms in coastal (and bay) waters from the shore to depths of 80 m. Catch rates for this species are highest during summer. The demand for sand flathead is not as high as that for the three species of *Neoplatycephalus* and sand flathead are generally marketed as an incidental part of the catch in the trawl and Danish seine fisheries. Sand flathead form less than 5% of the flathead catch off Lakes Entrance and about 30% of the flathead catch off central Victoria.

Long-nosed flathead, *P. caeruleopunctatus* (McCulloch), is a minor component of the flathead resources of coastal waters.

#### WHITINGS

School whiting *Sillago bassensis* Cuvier & Valenciennes occurs mainly on clean sandy bottom from the shore to depths of 80 m. The annual Victorian catch of about 600 tonnes is caught almost entirely by the Lakes Entrance Danish seine fleet which fishes the abundant and extensive school whiting on the broad sandy continental shelf at depths of 18 to 55 m.

Commercial and experimental trawling east of Wilsons Promontory (Amos 1976a, Winstanley 1977) and off central Victoria (Winstanley 1977, 1979a) have shown that commercially exploitable concentrations of school whiting occur from the shore to depths of 55 m. Off western Victoria the

species occurs where there is suitable shallow sandy bottom, for instance in Portland Bay.

Catch rates for school whiting are highest between autumn and spring (Winstanley 1979a). Amos (1976a) reported that catches are higher at night and at the time of the new moon.

King George whiting, *Sillaginodes punctatus* (Cuvier & Valenciennes), is largely exploited in the bays and inlets, but there is some commercial and amateur fishing on seagrass beds and on sandy patches among the shallow reefs off central and western Victoria. At times large whiting are taken in trawls or Danish seines on rough bottom at depths of 45 to 55 m off central Victoria.

Sand whiting *Sillago ciliata* Cuvier & Valenciennes are common in coastal waters but are not exploited commercially.

#### YELLOWTAIL KINGFISH

The yellowtail kingfish, *Seriola grandis* Castelnau, is a pelagic species which forms large schools in bays, inlets and on the continental shelf. Kingfish are caught off eastern Victoria from the shore to depths of 128 m from summer to winter; in bays, estuaries and inlets from spring to autumn; and in central and western Victorian coastal waters in late spring and summer.

#### SILVER TREVALLY

Young silver trevally, *Caranx georgianus* (Cuvier & Valenciennes), are common in inlets and estuaries; older fish are caught in coastal waters as deep as 110 m. Commercial catches from open waters are small and usually incidental in gillnets or trawl nets.

#### MACKERELS

Jack mackerel, *Trachurus declivis* Jenyns, occurs in all Victorian open waters during at least part of the year. Although their abundance is not known, jack mackerel stocks are regarded as being one of the outstanding unutilised resources of south-eastern Australian waters (Anon. 1978). They are least abundant during winter, when the main concentrations are off far-eastern Victoria (e.g. Anon. 1977c), and are most abundant in eastern Bass Strait, particularly during summer and autumn when large schools occur in surface and subsurface waters. Exploratory midwater trawling (e.g. Anon. 1976b, 1978b; Gorman & Graham 1974, 1976) has shown that schools occur mainly in mid and bottom waters during spring and early summer. Exploratory demersal trawling (Gresik 1977), pelagic trawling (Anon. 1976c) and



incidental commercial catches have shown that jack mackerel occur off western Victoria mainly during autumn and winter.

They are not actively sought by Victorian fishermen, and commercial catches are taken incidentally by demersal trawlers whose catches show that at least some mackerel occur close to the bottom during most months of the year with the largest catches taken at depths of 128 to 200 m in winter and spring. Incidental catches in demersal trawls and the infrequency of surface sightings indicate that off central Victoria jack mackerel are most abundant in late autumn and spring, when they occur mainly in mid and bottom waters.

Yellowtail, *T. maculochi* Nichols, and common or slimy mackerel, *Scomber australasicus* Cuvier & Valenciennes, also occur seasonally in coastal waters but are not actively exploited.

#### AUSTRALIAN SALMON

Two subspecies of Australian salmon, the eastern *Arripis trutta marginata* (Cuvier & Valenciennes) and the western *A. trutta esper* (Whitley), occur, mainly as schools of juveniles and young adults aged 0+ to 5+ years, in the bays, inlets and inshore open waters of Victoria (Stanley 1978). Younger fish of both subspecies school together in the protected bays and inlets, and older fish occur in the inshore waters.

Analysis of commercial catches shows that fish aged 1+ to 4+ years from the eastern subspecies are common in central Victorian waters and predominate off eastern Victoria; fish aged 1+ to 3+ years from the western subspecies are common as far east as the Gippsland Lakes and predominate off western Victoria. Although these young salmon are the basis of an annual 200 to 700 tonne Victorian fishery, the two subspecies are unusual in that, as they mature, they eventually separate and migrate into coastal waters of New South Wales and South and Western Australia where the adult fish reproduce and are exploited to a far greater extent.

#### SNAPPER

At least two stocks of snapper *Chrysophrys auratus* (Bloch & Schneider) occur in Victorian waters: the eastern stock which ranges between far eastern Victorian and northern New South Wales waters, and the western stock which ranges from Western Port to south-eastern South Australian waters (Sanders 1974). The status of snapper between these two regions, that is, from Wilsons Promontory to Mallacoota is not known.

Although snapper are occasionally taken in trawls on smooth bottom, between the shore and the edge of the continental shelf, they are most abundant on low profile reefs and on the fringes of rocky reefs. Juveniles occur in the bays, inlets, estuaries and coastal waters.

Each spring part of the western stock moves from the west along the coast and into Port Phillip and Western Port and returns to the west during the late autumn. Despite the regularity of this seasonal movement there is evidence that the whole stock does not migrate. For instance, snapper occur at the eastern and western extremities of the range during summer and in Port Phillip throughout the year.

The eastern stock is found off far eastern Victoria during the summer and autumn and off New South Wales during the rest of the year.

Snapper occur among coastal reefs off Corner Inlet and the Ninety Mile Beach during spring and summer and on similar reefs off Lakes Entrance during summer and autumn.

#### RED MULLET

The red mullet, *Upeneichthys porosus* (Cuvier & Valenciennes), occurs on sand, sponge and bryozoan-covered bottoms, on seagrass beds and at the edges of shallow reefs in coastal waters and bays. The annual commercial catch is low and is taken mainly by trawlers and Danish seiners; catch rates are highest during summer and autumn (Winstanley 1979a) at depths of 30 to 70 m. During autumn east of Wilsons Promontory, red mullet are most abundant in water of 20 to 50 m deep (Winstanley 1977).

#### MORWONGS

Tarakihi or jackass fish, *Nemadactylus macropterus* (Bloch & Schneider), is an important component of the offshore trawlfish resource off Victoria. This species occurs on sand, reef, sponge and bryozoan-covered substrates at all depths from the shore to 476 m (Anon. 1979). Juveniles as small as 10 cm caudal fork length occur in shallow waters (40 to 70 m) off central Victoria.

Commercial catches indicate that between late autumn and spring, tarakihi are most abundant at depths of 110 to 220 m off eastern Victoria (from Gabo Island to the Kingfish B oil platform) and at depths of 165 to 293 m off western Victoria. At other times of the year, smaller commercial catches are taken at depths of 110 to 146 m off eastern Victoria.

Off central Victoria, tarakihi are trawled at depths of 36 to 80 m and are most abundant during autumn (Winstanley 1979a).

Blue morwong *Nemadactylus valenciennesi* (Whitley) is caught incidentally in shark gillnets and in trawls on the continental shelf.

#### SNOEK

Snoek or barracouta are common in bays and coastal and offshore waters of southern Australia. Blackburn and Gartner (1954) described five south-east Australian populations of which three migrate to and from Victorian and adjacent waters at different times of the year to spawn: one population migrates from eastern Bass Strait to eastern Victoria and southern New South Wales waters during winter and spring; another population migrates from the eastern Great Australian Bight into western Victorian waters during autumn and winter; and the Bass Strait population which is most exploited, moves west to South Australian waters during spring and summer and returns during autumn.

Snoek school and feed in surface waters mainly during their spawning migrations and occur lower in the water column at other times of the year. Although they are only lightly exploited and are abundant in Victorian and adjacent waters, their accessibility to traditional trolling boats is believed to vary considerably with the distribution of their main foods—euphausiids and anchovies (Blackburn 1957). Victorian catches have therefore varied between 87 and 2 521 tonnes during the period 1970/71 to 1977/78. Demersal trawling catches (e.g. Winstanley 1979a) confirm that snoek may be abundant in coastal waters when trolling and the absence of surface schools suggest otherwise.

Although details of the distribution of snoek populations off Victoria are not known, they are caught from the shore to depths of at least 220 m. During late winter and spring they are trawled in waters 110 to 220 m deep off eastern Victoria and 110 to 128 m deep off western Victoria.

#### GEMFISH

Gemfish, *Rexea solandri* (Cuvier & Valenciennes), is a migratory school fish which is caught in demersal trawls at depths of 110 to 600 m over the upper part of the continental slope off eastern and western Victoria.

Off eastern Victoria, gemfish are caught mainly during spring in water 146 to 220 m deep and during summer in water 110 to 146 m deep. Off

western Victoria, gemfish are caught mainly during summer and autumn in water 275 to 567 m deep; small quantities are taken at other times in water 330 to 550 m deep. During winter, catches off Victoria are small in contrast with those taken from the large northbound spawning schools exploited in water 270 to 540 m deep off New South Wales.

#### FROSTFISH

Southern frostfish, *Lepidopus lex* Phillipps, occurs on the continental slope. Occasionally they are trawled in commercial quantities (e.g. Gresik 1977), particularly during summer and autumn, but they are not exploited regularly off Victoria.

#### TUNAS

Serventy (1941) reported the occurrence of five species of tuna in Victorian waters: southern bluefin tuna *Thunnus maccoyii* Castlenau, albacore *Thunnus alalunga* (Bonnaterre), yellowfin tuna *Thunnus albacares*, skipjack or striped tuna *Katsuwonus pelamis* (Linnaeus), and bonito *Sarda australis* (Macleay).

Southern bluefin tuna occur off far eastern Victoria from mid-winter until the end of summer and off eastern and central Victoria between November and May (Serventy 1941). Most years they are observed during autumn and small numbers are trolled off the Otway coast and western Victoria.

Albacore occur off eastern Victoria, eastern Bass Strait and, occasionally, off central Victoria during summer (Serventy 1941). Unlike the other tunas they are usually caught singly (Anon. 1954).

Yellowfin tuna also occur off far eastern Victoria during summer (Serventy 1941).

During summer and autumn, striped tuna are abundant off eastern Victoria (Serventy 1941) and, at least in some years, off Portland.

Bonito also occur off eastern and central Victoria during summer and autumn; they are occasionally caught as far west as Port Fairy (Serventy 1941).

#### TREVALLAS

The two species of trevalla exploited commercially are blue-eye or deepsea trevalla *Hyperoglyphe antarctica* (Carmichael) and warehou, snotgall trevalla or sea bream *Seriola lalandi* (Gunther) which is also referred to as "haddock" by Portland fishermen and anglers.

Deepsea trevalla are benthopelagic fish feeding mainly on macroplankton over the continental slope of eastern and western Victoria. Exploratory droplining (Winstanley 1979c) showed that they occur in water 180 to 770 m deep, and that catch rates are greatly influenced by seasonal schooling, dispersion and movement patterns. This exploratory fishing and subsequent commercial line, gillnet and trawl fishing have shown that trevalla are most abundant in water 350 to 500 m deep from winter to summer.

Commercial fishermen often misidentify warehou as deepsea trevalla although the former is readily distinguishable by its blotchy coloration and smaller mouth. Schools of juvenile warehou are often observed by divers and warehou are often taken in trawls in shallow coastal waters. Adult warehou usually occur over reefs in coastal waters and over low profile reefs and sandy bottoms on the continental shelf to depths of 220 m. The largest commercial catches are taken in gillnets and, occasionally, trawls at depths of 110 to 220 m off eastern Victoria. Small quantities are trawled off central Victoria during most months and occasional large catches have been trawled at 110 to 128 m off western Victoria.

Mackerel trevalla *S. maculata* (Forster) also occurs offshore from eastern and western Victoria (Gresik 1977) but its distribution, abundance and degree of exploitation are uncertain because fishermen confuse this species with warehou.

#### FLOUNDERS

The species forming most of the flounder catch from Victorian coastal waters is the longsnouted flounder *Ammotretis rostratus* Gunther, which fishermen commonly referred to as "sole"; the remainder of the catch consists of greenback flounder *Rhombosolea tapirina* Gunther and spotted flounder *Ammotretis tudori* McCulloch.

The annual commercial catch of flounders from coastal waters is small and mostly incidental in the catches in the Danish seine, trawl and gillnet fisheries off eastern and central Victoria. Catch rates off eastern Victoria show no clear seasonal pattern but those off central Victoria are consistently highest during winter and spring (Winstanley 1979a).

#### SPECIATION OF EXPLOITED STOCKS

Although in this paper speciation of fishes is not discussed, it is appropriate to mention briefly the role which the periodic barrier across Bass Strait must have played in the speciation of exploited

species such as Australian salmon, snoek, snapper and the flatheads. The end of the range of each of these exploited species is somewhere in Bass Strait. As well as having distinct migration patterns some populations of pelagic species to the east and west of Bass Strait have differences in anatomy, feeding and growth. Examples include the growth rates of snapper stocks (Sanders & Powell 1979) and the anatomy of the Australian salmon subspecies (Malcolm 1961). The ancestral stocks of these species have evidently been divided by the Bass Strait barrier and speciation has occurred as a result of the differing physical and biotic environments off southern and eastern Australia.

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